Paging System Technology

The aim of a paging system is to deliver important audio announcements to people working in a facility at the proper level and with sufficient clarity to make the announcement easily understood. The two most common ways to accomplish this is to use either 70V centralized amplifiers with passive speakers or self-amplified speakers operating from a 24V DC power supply.

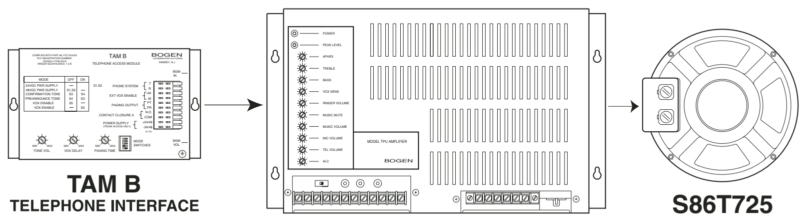
Pages 64-67 explain 70V systems and pages 68-69 explain self-amplified systems. Speaker layout, wiring methods, and phasing are the same for either technology and are covered on pages 70-73.

Central-Amplified Systems - pages 64-67
Self-Amplified Systems - pages 68-69

What Is A 70V System?

70V Paging Systems consist of:

- **A Centralized Amplifier** which offers a variety of features to enhance voice and music reproduction as well as easy system expansion.
- **Speakers** that connect with a simple 2-wire installation because the audio power is supplied from the centralized amplifier.
- **An Interface Device** that connects the paging system to the telephone system. (Depending on the telephone system and amplifier, an interface device may not be needed.)



TAM B
TELEPHONE INTERFACE

TPU 100
CENTRALIZED AMPLIFIER

S86T725
SPEAKER

Why Use 70V Outputs?

Low Currents Allow Long Runs

Why do distributed sound systems use centralized amplifiers with 70V output signals? Because 70V systems can handle extremely long lengths of wire to connect the speakers to the amplifier, and they can power a large number of speakers in each system.

When sending power signals over long distances, it is important to minimize the amount of current flowing in the wire. High currents allow too much power, or electrical energy, to be wasted in wires in the form of heat.

The power (P) lost in the wire is related to the square of the current (I^2), so reducing the current in the wires a little reduces the power lost in them considerably. In fact, reducing the current flowing in a wire by a factor of 2 will reduce the power loss by a factor of 4.

$$P = I^2 * R$$

P: Power Lost In Wires (Watts); I: Current Flowing In Wire (Amps); R: Resistance of Wire (Ohms)

However, the power the load demands and the output level of the amplifier determines the amount of current that must flow in the speaker wires (Ohms' law in action).

$$I = P / V$$

I: Current Flowing In Wire (Amps); P: Power Needed By Load (Watts); V: Amplifier Output Voltage (Volts)

So to lower the amount of power lost in the wires, the voltage that the amplifier uses to drive the load is increased. By doing this, the current in the wires can be reduced while still supplying the same power to the load (for the same power P, any increase in V will lower I).

Of course you cannot just change the voltage driving a load from one level to another without also making the load compatible with the new voltage level. To ensure compatibility, 70V systems use transformers on the speakers that change the high 70V amplifier output levels to lower levels that are compatible with typical 8-ohm speakers.

Easy To Control Speaker Power Draw

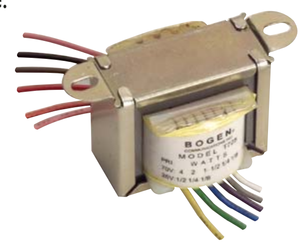
The output of a central paging amplifier is designed to limit the maximum output voltage that can be supplied to the speakers. This maximum output voltage remains the same regardless of the amplifier's power capacity. Because the output voltage is limited, speaker manufacturers can design products that consume a specific amount of power from the amplifier. This is beneficial in two ways.

First, the speakers will not consume more power than they are designed for; so, they cannot blow out from using an amplifier that's too powerful. Second, since each speaker's power consumption is known, the correct amplifier power for the paging system is simply the total power drawn by all the speakers.

What Makes A 70V Speaker?

Step-Down Transformer

70V paging speakers have a step-down transformer, which is used to convert the high-voltage/low-current amplifier signal of the central paging amplifier to the low-voltage/high-current signal that speakers use.



Taps

The primary side of the step-down transformer (the side that connects to the amplifier) has a number of connections (called taps or power taps) that can be used to select the peak power the speaker will consume from the amplifier.

Why Taps?

The selection of the power tap has an effect on both the amplifier power needed for the system and the volume of the speaker. The more power a speaker consumes, the louder the sound from the speaker. By tapping speakers for lower power in quiet areas and for higher power in noisier areas, the sound level of the paging system can be controlled and balanced.

It is important that speakers be tapped correctly for the area that they will be used in. Setting all the speakers for the same power regardless of the amount of noise in different areas will cause balance problems. If the amplifier is adjusted to produce adequate paging levels in the noisy areas, the paging levels in the quiet areas will be too loud or vice versa. Selecting the proper tap setting is not difficult, but it does require knowing the level of ambient noise in different areas. (See Sound Pressure Levels Chart on page 77.) It is always better to use the next higher wattage tap if there is any doubt about the speaker being sufficiently loud for the area.

Of course, the best way to determine how effectively a system covers an area is to test it. Never install a paging system and leave the site without testing it. Sound adjustments or additional speakers may be needed. Some paging equipment, such as Bogen's PCM2000, UTI1, and UTI312 paging interfaces include a test tone that is sent to all speakers in the system so installers can check the system installation. For other systems, the installer can have pages made while the installer walks the area to listen for appropriate sound levels and uniform coverage of the system to find out if and where adjustments need to be made, and to make sure that all speakers are properly connected.

Easy Design™ Without Taps

To make designing paging systems as easy as possible, Bogen offers a line of Easy Design™ speakers. These speakers do not require tapping and allow for on-the-fly adjustment of speaker paging levels. All the information that is needed to design a complete system are the dimensions of the different paging areas and the type of environment. With this basic information, you can use the Easy Design speaker line to quickly design a robust, professional, and powerful paging system. (See pages 3-9 for more information.)

Amplifier Output Types

70V Output

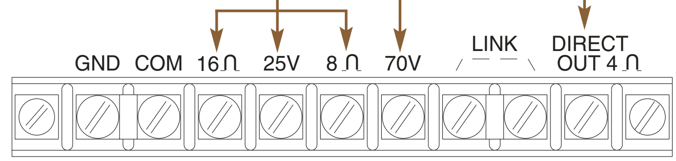
A 70V output is available on Bogen amplifiers and is the primary type of output for paging systems. A step-up output transformer in the amplifier provides the high 70V output signal. All speakers with step-down transformers (rated for 70V systems) are connected to this output.

Other Output Types (25V, 16- and 8-ohm)

There are a number of other standard speaker impedances that Bogen amplifiers can be connected to. These outputs provide the correct speaker signal levels for different configurations of low impedance speakers. The lower voltage, 25V, output is provided on many Bogen amplifiers for use in paging installations that require a speaker voltage of less than 70V to meet building code requirements.

Direct Output

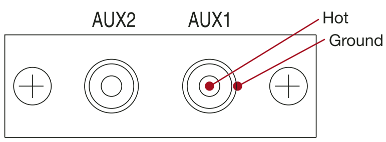
Direct outputs are used with low impedance speakers. These outputs have an exceptional low frequency (bass) response, providing the fuller sound that low impedance speakers can reproduce. Certain Bogen amplifiers, designed for general purpose sound reinforcement applications, include this feature which allows the step-up output transformer to be bypassed for direct connection to the power amplifier's output.



Amplifier Input Types

Auxiliary Input (AUX)

The Auxiliary input is the most common type of input used in paging. This input is designed to connect to most music sources, such as a CD player or tuner. Usually the connector for such an input is a Phono jack (also called an RCA jack). It connects to other equipment using standard audio cables.



Phono (RCA) Input Jacks

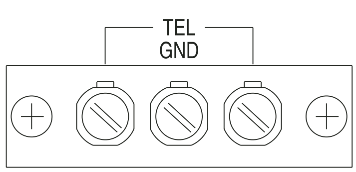
The AUX input has an outer connection that is directly connected to the equipment's ground and a center connection that is the "hot" input. AUX inputs, sometimes referred to as Hi-Z or high impedance inputs, have a high input impedance so that they won't put too much of a load on the source equipment's output. This type of input is "unbalanced". You must use shielded cable with this type of input in order to avoid getting noise induced into the system.

Normally, connections between source equipment and the amplifier's AUX input should not be too long, about 6 feet. The problem with long connections is that the cable acts like an antenna, picking up any electrical noise in the area. The longer the cable, the more noise that is picked up.

Telephone Input (TEL)

The TEL Input is so named because it was designed to be compatible with page port outputs of telephone systems. The TEL input is a 600-ohm transformer-coupled input that:

- matches the impedance of the telephone port to provide proper interfacing
- electrically isolates the amplifier from the PBX or Key System
- provides a balanced input with a great deal of noise immunity



Telephone Input Screw Terminals

Bogen's TEL inputs do not have to be shielded, but it is always a good idea to provide more noise immunity (normally a ground terminal is available on the input for the shield connection). Higher noise immunity allows the amplifier to be located much farther away from the source equipment than what an unbalanced input will allow.

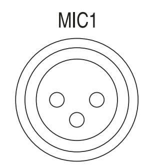
The input transformer is not designed to pass loop current from a telephone line. Any time you want to connect to a telephone station or trunk port, you will need to use a telephone interface module like the TAMB, which converts the telephone signal into a "dry" audio signal compatible with the amplifier's TEL input.

Microphone Input (MIC)

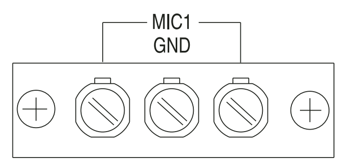
The traditional paging amplifier input is the Microphone input. MIC inputs were the primary announcement source until connection to the telephone system became possible. MIC inputs are still used in public address applications today.

When connected properly, a microphone can be hundreds of feet away from the amplifier and still provide clear, quiet audio.

MIC inputs are the most sensitive of all the amplifier inputs and tend to pick up the stray electrical noise in an area. To combat the noise pickup problem, MIC inputs are balanced. Just like TEL inputs, the balancing of the input provides a high level of noise immunity. MIC inputs are also made to have a fairly low input impedance, which makes it difficult for electrical noise to get induced. The low impedance effectively keeps down noise, which makes its signal level smaller.



Balanced Microphone "XLR" Type Connector



Balanced Microphone Screw Terminals

Microphone cable is always shielded. The input requires three connections – two for the balanced signal and one for the shield ground. You can reverse the balanced signal leads and the system will still work properly. However, if you mis-wire the ground connections, the amplifier can become unstable and start to oscillate. When this occurs, the amplifier may heat up enough to cause its protection circuits to shut it down or it may produce very distorted sound.

- see page 81

Designing 70V Systems

1 Determining Quantities

Figuring out how many speakers you need for your application is simple. You only need the dimensions of the area in which the paging system will be installed.

- For Bogen's Easy Design™ line speakers, refer to the charts on pages 6-8.
- For speakers with multiple tap settings, refer to this section for information.

CEILING SPEAKERS

Models CSD1X2, SM4T, S86/S810T725PG8W and variations.

To determine the number of ceiling speakers your installation requires, simply divide the area's total square footage by the speaker coverage as indicated in this chart.

Ceiling Height (ft.)	Coverage (sq. ft.)
8	250
10	400
12	580
14	780

Total Area (Sq. ft.) ÷ Speaker Coverage = # of Speakers

WALL BAFFLE SPEAKERS

Models WBS8/S810T725 & variations.

To determine the number of wall baffle speakers your installation requires, simply divide the area's total square footage by 600 square feet.

Coverage is 600 sq. ft. per speaker

Total Area (Sq. ft.) ÷ 600 Sq. ft. = # of Speakers

HORN LOUDSPEAKERS

Models SPT5A/15A/30A.

To determine the number of horn loudspeakers your installation requires, simply divide the area's total square footage by the speaker coverage as indicated in the chart below.

See chart below

Total Area (Sq. ft.) ÷ Speaker Coverage = # of Speakers

2 Determining Taps

To determine tap settings, use the appropriate chart.

Recommended Ceiling Speaker Tap Settings

Ambient Noise Range	Ceiling Height (ft.) 8	10	12	14
Low Noise (55 dB-65 dB)	1/2W* 1/4W+	1/2W* 1/4W+	1W	1W
Medium Noise (65 dB-75 dB)	1W* 1/2W+	1W* 1/2W+	2W	4W
High Noise (75 dB-85 dB)	4W			
Very High Noise (85 dB-95 dB)				

*SM4T Tap Settings +S86/S810 Tap Settings

Recommended Wall Baffle Tap Settings

Ambient Noise Range	Tap Setting
Low Noise (55 dB-65 dB)	1W
Medium Noise (65 dB-75 dB)	4W
High Noise (75 dB-85 dB)	
Very High Noise (85 dB-95 dB)	

Recommended Horn Tap Settings

Model	Ambient Noise Range	Speaker Power Taps (Watts)	Coverage (sq. ft.)
SPT5A	Low Noise (55 dB-65 dB)	1.25W	6,500
SPT5A	Medium Noise (65 dB-75 dB)	7.5W	6,500
SPT15A	Medium Noise (65 dB-75 dB)	.9W	7,000
SPT15A	High Noise (75 dB-85 dB)	3.8W	6,500
SPT15A	Very High Noise (85 dB-95 dB)	15W	2,500
SPT30A	High Noise (75 dB-85 dB)	3.8W	7,000
SPT30A	Very High Noise (85 dB-95 dB)	30W	5,500

3 Determining Amplifier Power

To determine the total power your installation will require, simply multiply the number of speakers by the tap wattage.

Total Speakers × Tap Wattage = Minimum Amplifier Power

See page 75 for Wire Loss Information

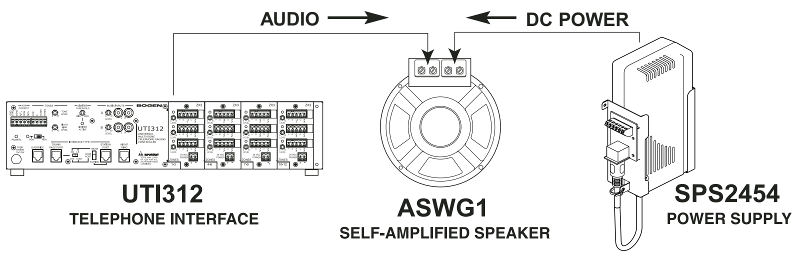
Amplifier Selection

Once you know the minimum amplifier power your system requires, refer to the *Amplifier Charts* on pages 78-79.

What Is A Self-Amplified System?

Self-Amplified Paging Systems consist of:

- **Self-Amplified Speakers** each contain an individual, built-in, miniature amplifier that drives the speaker directly. Each speaker requires 4 wires. Two wires supply the raw 24V DC voltage to power the speaker's internal amplifier and another 2 wires supply the low level audio paging signal to the amplifier's input. All amplified speakers contain volume controls to adjust output level.
- **A Power Supply** or multiple power supplies which supply the raw 24V DC voltage that will power the amplifier built in to each self-amplified speaker. Several power supplies can be located in convenient areas in the facility.
- **An Interface Device** that connects the paging system to background music sources and the telephone system and supplies a telephone level audio paging signal to all the speakers in the system. (Depending on the telephone system and number of speakers in the system, an interface device may not be needed.)



Why Use Self-Amplified Technology?

Low Signal Levels Prevent Crosstalk

In certain installations it may be desirable to use conductors in an existing telecommunication cable to deliver paging to different floors or areas in a facility. 70V amplifier signals would not be appropriate to run in the same cable with analog telephone signals since their high level could cause crosstalk in the other telephone circuits in the cable. Because the audio signal levels supplied to the inputs of the amplified speakers are similar in level to analog telephone levels, there will be no crosstalk of the paging system in the telephone lines.

The raw 24V DC power needed by the self-amplified speaker can also be carried in the telecom cable since it contains no interfering signals, but care must be exercised to make sure the length of cable will not cause too much voltage to be lost in the cable.

Convenient System Expansion

A self-amplified system can be expanded by adding extra speakers and power supplies as required. They are extremely scalable due to the fact that each speaker is an amplifier unto itself. It is also easy to connect additional power supplies where needed to power the speakers. In some instances there may not be sufficient audio signal level available for the speaker's input. In these instances a small buffer can be installed inline to boost the signal level.

Self-amplified speakers can also be used to expand 70V paging systems in cases where the added speakers would overload an existing central 70V amplifier. The same buffer that is used to boost signal level can be used to reduce the large 70V speaker signal to a level that is compatible with the input of self-amplified speakers. A suitable power supply can be located near the expansion speakers to power their internal amplifiers. This approach can be used instead of replacing the central 70V amplifier with a larger one to handle the extra speakers.

Cost Effective for Small Installations

Self-amplified speakers can be very cost effective in small systems since they provide scalability in small increments. The centralized amplifiers in 70V systems are typically available in set output power levels steps that start at 6 or 10 watts and increment by 10 watts or more from model to next higher powered model. In small applications that require only a few watts of paging, the extra power capability of the 70V amplifiers may not be an advantage due to the higher cost associated with the amplifier's extra power, especially if it will not be used in the future.

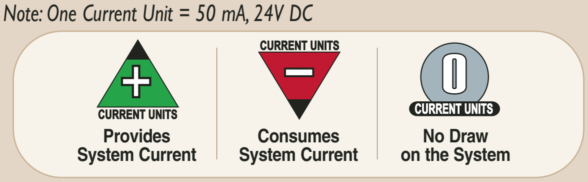
Self-amplified systems can be designed with much smaller output level power steps so that only the necessary audio power is installed in the facility. This can result in a lower cost of equipment especially where the desired power level is considerably less than the smallest applicable 70V amplifier output level.

Understanding Current Units

Self-Amplified paging systems are made up of equipment that consume or provide operating current. To operate properly, the system needs to provide at least as much 24V current as it consumes.

Each product has a Current Units number. This number is either positive, negative, or zero to indicate how much current it provides or consumes from the system.

Note: One Current Unit = 50 mA, 24V DC



What Makes A Self-Amplified Speaker?

Built-In Amplifier

As the name suggests, all self-amplified speakers contain their own miniature amplifier. These amplifiers range in size from 1 watt, which are used on cone speakers, up to 15 watts, which are used on the SAH15 and AH15A horn speakers.

Bogen's latest line of self-amplified horns use a revolutionary digital switching amplifier. Unlike conventional analog amplifiers, this advanced technology produces very little heat when it operates. It produces so little heat that all it needs to dissipate the waste heat are the copper interconnecting traces on the printed circuit board instead of the typical large aluminum heatsinks. Because it produces so little heat it also draws considerably less power from the power supply. Why? Because it is not wasting half of the power supply energy it consumes as heat.

More typical in the industry are speakers that employ analog amplifiers, which produce considerable waste heat while operating. They typically release half the 24V power they consume in the form of heat, and heat is a major contributor to the failure of an amplifier.

The amplifiers in Bogen's AH series of self-amplified horns are analog but rid themselves of waste heat through their large cast aluminum end bell that works as an excellent heat sink, quickly and effectively removing excess heat. Competitve products using plastic end bells don't have this cooling advantage.

4 Wires

All self-amplified speakers require 4 wires to make the necessary connections. Two of the connections are used to provide 24V DC power to the built-in amplifier. The other connection pair to a self-amplified speaker is for the audio signal input.

The general audio signal level is the same as what you would find on any analog telephone line. The input is transformer balanced, also similar to the inputs found on telephone systems. The balanced nature of the input greatly reduces interference and noise caused by equipment running in the facility. The use of an actual transformer provides electrical isolation between the input leads and the actual amplifier, which protects it from ground loops and RF interference, and provides an all-around rugged input.

Designing Self-Amplified Systems

1 Determining Quantities

Figuring out how many speakers you need for your application is simple.

- For Bogen's Ceiling and Wall Baffle Speakers, you will need room dimensions.
- For Bogen's Horn Speakers, you will need room dimensions and ambient noise levels.

CEILING SPEAKERS

Models ACD2X2, ASWG1, ASWG1DK.

To determine the number of ceiling speakers your installation requires, simply divide the area's total square footage by the speaker coverage as indicated in this chart.

Ceiling Height (ft.)	Coverage (sq. ft.)
8	250
10	400
12	580
14	780

Total Area (Sq. ft.) ÷ Speaker Coverage = # of Speakers

WALL BAFFLE SPEAKERS

Model ASWB1

To determine the number of wall baffle speakers your installation requires, simply divide the area's total square footage by 600 square feet.

Coverage is 600 sq. ft. per speaker

Total Area (Sq. ft.) ÷ 600 Sq. ft. = # of Speakers

HORN LOUDSPEAKERS

Models AH5A, SAH5, AH15A, and SAH15

To determine the number of horn loudspeakers your installation requires, simply divide the area's total square footage by the speaker coverage for the noise level in the area as indicated in the chart below.

	Ambient Noise Range	Coverage	Volume Setting
SAH5A, AH5A	Low Noise (55 dB-65 dB)	8050	LOW
SAH5A, AH5A	Medium Noise (65 dB-75 dB)	6955	HIGH
SAH15A, AH15A	Medium Noise (75 dB-85 dB)	6955	LOW
SAH15A, AH15A	High Noise (75 dB-85 dB)	6500	MEDIUM
SAH15A, AH15A	Very High Noise (85 dB-95 dB)	2600	HIGH

Total Area (Sq. ft.) ÷ Speaker Coverage = # of Speakers

2 Determining Power Supply Capacity

To determine total 24V DC Power Supply size requirement use the equation below.

1. Add all the − numbers of the Self-Amplified speakers and volume controls together.
2. Select a Power Supply (or power supplies) with a + number(s) equal to or greater than the total − amount.

For more information on − + see pages 21 and 68.

See page 28 for Power Supply Selection.

See page 75 for Maximum Wire Lengths

Speaker Layout

The layout of the speakers should be planned before installation begins. The spacing of the speakers can be adjusted so that the speakers are evenly spaced in a row. Some adjustments may need to be made due to sound obstructions that may be in the area such as high shelving, cubicle walls, etc.

Ceiling Speakers

Layout starts in one corner of the area. The first speaker should be positioned from each wall a distance approximately equal to the ceiling height of the room (dimension A).

The next speaker in row 1 should be spaced a distance approximately equal to twice the height of the ceiling (dimension B). Each additional speaker in the row should use this same spacing.

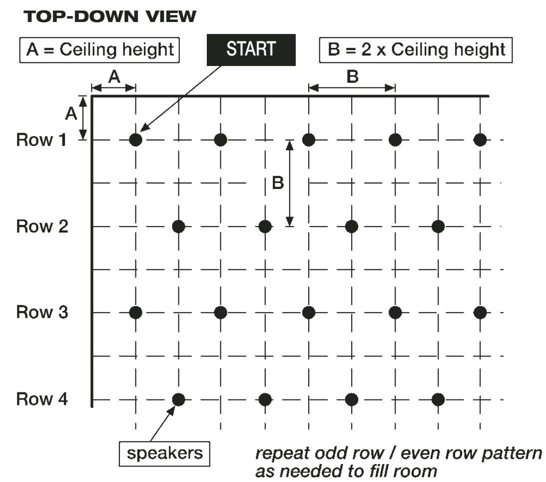
Row 2 starts at twice the ceiling height distance (B) from row 1 and twice the ceiling height (B) from the wall. The other speakers in this row are also spaced at twice the ceiling height.

Row 3 is again spaced at twice the ceiling height (B) from the previous row. The first speaker starting this row is positioned at one ceiling height distance (A) from the wall (similar to row 1).

Continue this pattern of alternating rows until the room is covered.

The spacing of the speakers can be adjusted so that the speakers are evenly spaced in a row and are more aesthetically pleasing.

Ceiling Speaker Layout



Horn Loudspeakers

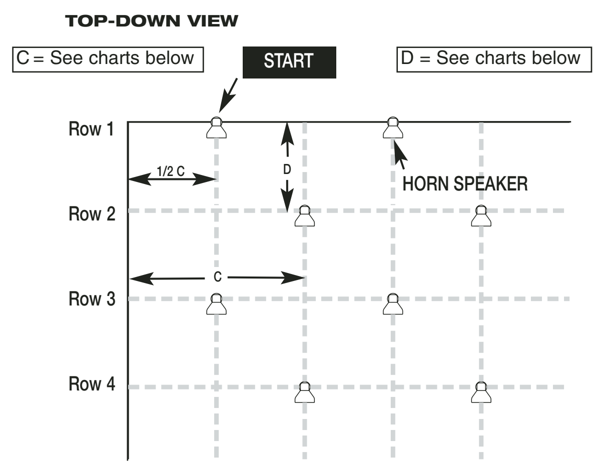
Desired mounting height, barring obstructions, is 15 to 20 feet, with the speakers angled downward toward the listening area and facing in the same direction. Follow the diagram for the layout of the horn speakers while using the charts below to define the lettered dimensions for each specific speaker.

Begin in one corner of the area. The first speaker in Row 1 is positioned a distance equivalent to (1/2C). The next speaker in Row 1 should be a distance equivalent to (C) from the first speaker. Each additional speaker in the row should use this same spacing. Row 2 starts at the indicated distance (D) from the wall. Using the diagram as a guide, fill in the remaining rows in this same alternating pattern until the entire area is appropriately covered.

For areas that include high shelving or corridors, speakers should be installed so that they project down the aisles between the shelves or down through the corridors.

The spacing of the speakers can be adjusted so that the speakers are evenly spaced in a row.

Horn Speaker Layout



NOTE: Each environment is unique. This layout plan is general in nature and may not be applicable for every installation.

Model	Ambient Noise Range	C	D	Volume Setting
SAH5A, AH5A	Low Noise (55 dB-65 dB)	115 ft.	70 ft.	LOW
SAH5A, AH5A	Medium Noise (65 dB-75 dB)	107 ft.	65 ft.	HIGH
SAH15A, AH15A	Medium Noise (75 dB-85 dB)	107 ft.	65 ft.	LOW
SAH15A, AH15A	High Noise (75 dB-85 dB)	100 ft.	65 ft.	MEDIUM
SAH15A, AH15A	Very High Noise (85 dB-95 dB)	65 ft.	40 ft.	HIGH

Model	Ambient Noise Range	C	D	Volume Setting
HS7EZ	Low Noise (55dB-65 dB)	120 ft.	80 ft.	1/2 Rotation
HS7EZ	Medium Noise (65dB-75 dB)	100 ft.	60 ft.	Full Clockwise
HS15EZ	High Noise (75dB-85 dB)	100 ft.	60 ft.	1/2 Rotation
HS15EZ	Very High Noise (85dB-95 dB)	65 ft.	40 ft.	Full Clockwise
HS30EZ	Very High Noise (85dB-95 dB)	90 ft.	55 ft.	Full Clockwise

Model	Ambient Noise Range	Speaker Power Taps (Watts)	C	D
SPT5A	Low Noise (55 dB-65 dB)	1.25W	100 ft.	65 ft.
SPT5A	Medium Noise (65 dB-75 dB)	7.5W	100 ft.	65 ft.
SPT15A	Medium Noise (65 dB-75 dB)	0.9W	105 ft.	67 ft.
SPT15A	High Noise (75 dB-85 dB)	3.8W	100 ft.	65 ft.
SPT15A	Very High Noise (85 dB-95 dB)	15W	63 ft.	40 ft.
SPT30A	High Noise (75 dB-85 dB)	3.8W	103 ft.	68 ft.
SPT30A	Very High Noise (85 dB-95 dB)	30W	97 ft.	57 ft.

Speaker Layout

Wall Baffle Speakers

The layout of the speakers should be planned prior to installation. Because wall baffle speakers are designed to project forward, it is best to aim them in the same direction, as this provides for both greater coverage and clarity. You can use the building's roof pillars or other available supports for mounting the wall baffles. In some cases, it may be necessary to mount the wall baffles on opposing walls. In these cases, the speakers will project sound in opposing directions.

Chart for 70V and 25V passive speakers

Ambient Noise Range	Tap Setting
Low Noise (55 dB - 65 dB)	1W
Medium Noise (65 dB - 75 dB)	4W
High Noise (75 dB - 85 dB)	
Very High Noise (85 dB - 95 dB)	

Chart for self-amplified speakers

Ambient Noise Range	Facing Speaker Distance	Volume
Low Noise (55 dB-65 dB)	< 40 ft.	Med
	40 to 60 ft.	High

• *Hallway/Room*

Wall baffle speakers work well with rooms and hallways that are 20' to 60' wide. Layout starts at one end of the hallway or room. The first speaker should be installed 10' from the end of the hallway or room. The next speaker on that wall should be installed 20' from the first speaker, as should any additional speakers required to cover the length of the hallway or room.

The first speaker on the opposing wall should be installed 20' from the end of the hallway or room, thereby staggering the speakers. Each additional speaker should also be installed 20' apart from the previous one. (See Figure 1.)

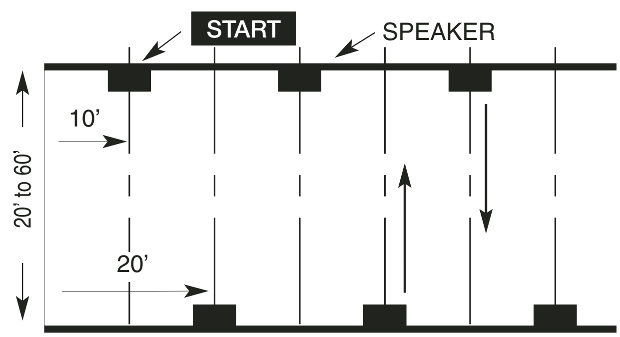


FIGURE 1

• *Open Area*

The number of speakers needed to cover an open area and the layout of those speakers is contingent upon the availability of suitable mounting points in the area to be covered.

Layout starts in one corner of the room. The first speaker should be installed 10' from the corner of the room with each additional speaker in the first row installed in increments of 20' from the first. Based on Figure 2, install the next row of speakers 30' from the first row and 20' from the wall with increments of 20' between each speaker. The third row would follow the example of the first and each additional row would continue this pattern of alternating rows until the whole area is covered.

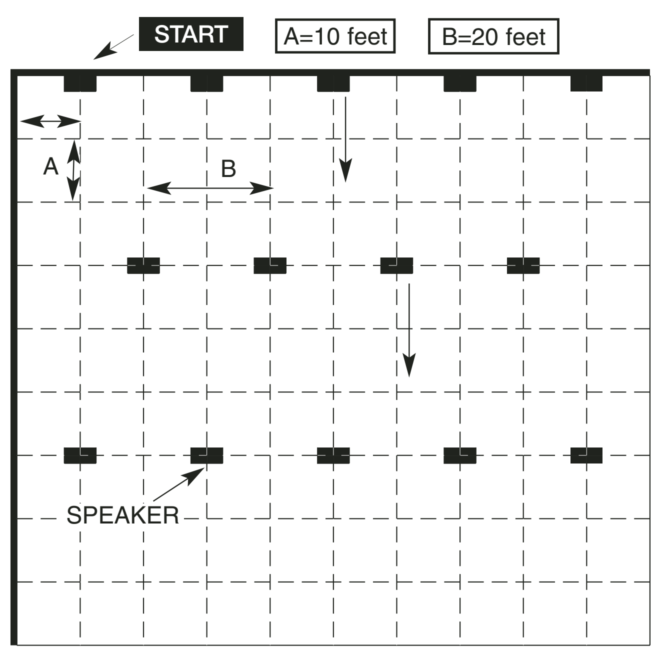


FIGURE 2

Site Survey

Designing a system and determining an installation's requirements are quite simple. After you set up your first system, the steps will appear logical and soon the process will become routine.

Before you begin designing or quoting a job, you will need some basic information regarding the site and the end-user's needs. Use the Site Survey Check List below to ensure that you collect all the information you will need to complete the design of the paging system. When you have completed the check list, create a bill of material for the equipment you need for the installation's sound system. Refer to the Easy Design™ Guide (pages 5-9), page 67 for 70V systems, or page 69 for 24V systems.

Tools Needed

You will need to bring the following tools with you when you visit the installation site:

- measuring wheel/tape measure
- sound pressure meter
- calculator
- Bogen Products catalog
- Photocopies of Site Survey Check List (this page)

Obtain a copy of the floor plan, or create sketches of any areas that may require special design considerations (high shelving, speaker mounting locations, exposed beams, amplifier location, etc.).

A successful paging system depends on more than just understanding the physical requirements of the installation site, it also depends on knowing which special paging features the user will benefit from and use on a daily basis. These include zone paging, tone controls, night ringer, feedback elimination, ambient noise sensors, multiple inputs, etc.

Site Survey Check List

This Site Survey Check List will help to determine the paging system equipment needed for installations. Photocopy this page and bring it with you when you visit installation sites. You may need several copies of this chart for each installation.

Section I – *SYSTEM NEEDS* concerns the requirements of the entire installation.

Section II – *SPECIFIC AREA NEEDS* concerns specific areas within the installation.

I. *SYSTEM NEEDS*

Note: Installations that contain areas with different style environments or sound levels may require Section II to be filled out separately for each area. Be sure to make enough photocopies of this page for this purpose.

a. **What Type of Telephone Port Will Be Available for Connection to the Paging System?** *(see page 76)*
❑ Loop Start ❑ Ground Start
❑ Page Port ❑ Analog Station Port
❑ Other: ________________

b. **How Many MIC Inputs Needed?** ______ *(see page 66)*

c. **How Many AUX Inputs Needed?** _____ *(see page 66)*

d. **Is Zone Paging Required?** ❑ Yes ❑ No *(see pages 31-35)*
If yes, how many zones: ______________

e. **Is Talk Back Required?** ❑ Yes ❑ No *(see page 50)*
If yes, in individual zones? ❑ Yes ❑ No *(see pages 32-33)*
If yes, system-wide (no zones)? ❑ Yes ❑ No *(see page 50)*

f. **Is Group Paging Required?** ❑ Yes ❑ No *(see pages 31-35)*

g. **Are Time Tones Needed to Signal Shift Changes?**
❑ Yes ❑ No *(see page 31-33, 51)*

h. **How Can Headend Equipment Be Mounted?**
❑ Rack ❑ Wall ❑ Shelf

i. **System Features Needed**
❑ Aphex™ Aural Exciter ❑ Variable Loudness Contour Control
❑ Automatic Level Control (ALC) ❑ Graphic Equalizer
❑ Bass & Treble Controls ❑ Variable Mute
❑ Automatic Mute ❑ Manual Mute
❑ MOH Output ❑ Night Ringer

j. **Any Technology Preference?**
❑ None ❑ 70V Central Amplifier ❑ Self-Amplified 24V Equipment

II. *SPECIFIC AREA NEEDS*

a. **Area Name/Description:** ____________________

b. **Area Dimensions:**
Length ______________ ft. Width ______________ ft.
Square Footage _________ sq. ft. Ceiling Height _________ ft.

c. **Ambient Noise Level:** _________ dB
(to estimate, see chart on page 77)

d. **Will There Be Large Changes in Ambient Noise Levels in the Area?** ❑ Yes ❑ No *(see page 38, 49)*
If yes, note range: _________ dB to _________ dB

e. **Environment:**
❑ Office/Professional/Retail Store ❑ Factory/Industrial
❑ Institutional/Remote Public Area ❑ Warehouse
❑ Aisles created by high storage racks ❑ Hallways
❑ Cafeteria/Break Room ❑ Auditorium
❑ Loading Docks/Outdoor Areas ❑ Other: ______________

f. **Where Will the Speakers Be Placed?**
❑ Indoors ❑ Outdoors

g. **How Can the Speakers Be Mounted?**
❑ Suspended/Drop Ceiling* ❑ Wall**
❑ Beams, Columns, Other Structures ❑ Ground

** Make note of any changes in surfaces or positions for actual speaker mounting.*
*** Make note of any changes in wall angles, surfaces, or height.*

h. **Are Volume Controls Mounted on Each Speaker Needed?**
❑ Yes ❑ No

i. **Are Wall-Mounted Attenuators Needed for Area's Volume Control?** ❑ Yes ❑ No *(see page 20, 27)*

j. **Is Feedback Elimination Equipment Needed?** ❑ Yes ❑ No *(see page 51)*

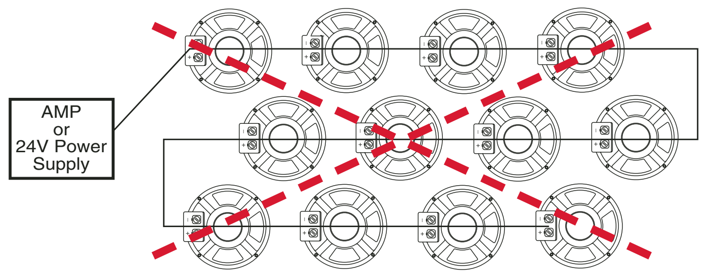
k. **Is Background Music Needed?** ❑ Yes ❑ No
If yes, BGM source: *(see pages 53-55)*
❑ Tuner
❑ Tape Player/Tuners
• Antenna Available for tuners? ❑ Yes ❑ No
❑ CD Player ❑ Other: ______________

Speaker Wiring

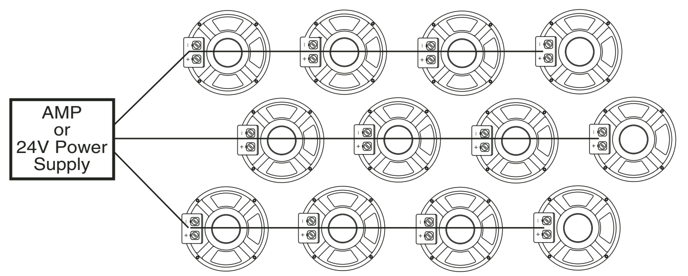
Speaker Wiring Patterns

Because distributed paging systems involve a great number of speakers and long distances, the manner in which the speakers are wired is of interest. Deciding on how to wire the speakers depends on whether separate zones of speakers are needed, how many lines back to the amplifier are reasonable, and how easy it will be to troubleshoot the system in the future.

How you wire a speaker system may require some tradeoffs. The simplest way is to parallel all the speakers on one very long run of wire. This approach leads to some problems. First, the amount of power lost in a long run of wire may not allow the required amount of 70V speaker signal, or 24V DC voltage for self-amplified paging systems, to get to the farthest speakers. Second, if there should be a short on the wire run, it would take down the entire run. In order to locate it, you would need to disconnect each speaker until the failed one is found.



Single Wire Run (Not Recommended)



Multiple Wire Runs (Preferred)

Multiple Wire Runs

A more practical approach is to wire each row of speakers in an area together and run a lead wire from this row back to the amplifier. The objective is not to have so many speakers daisy-chained together that it makes troubleshooting impossible. Wire runs can be separated to determine in which run the problem exists.

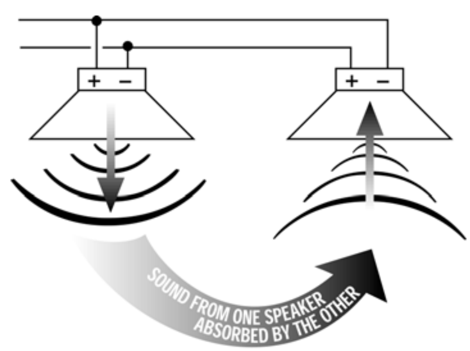
Speaker Phasing

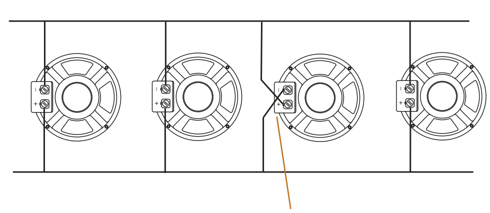
As the voltage on a speaker changes from plus to minus, the speaker cone moves from pushing out to pulling in. If you reverse the polarity, the speaker responds in the opposite manner.

If a speaker is pushing out and an adjacent speaker is pulling in, some of the pressure caused by the speaker pushing out will be absorbed by the speaker pulling in. These two speakers are out of phase.

In a paging system, all the speakers should be in phase so that they all push out at the same time. Out of phase speakers operate perfectly well and will not cause any harm to a paging system, but will tend to diminish the bass response in the area around the out of phase speaker.

The important thing is to wire all the same polarity (+ or -) connections together. This will ensure that the speakers in the system all work in unison. All paging speaker connections have a polarity indicator. It may be a color code, plus (+) and minus (-) symbols, or a red dot.



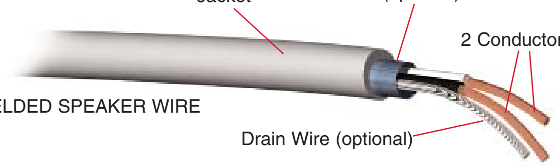


Reversed Connections
in 70V System

Wire Types

Speaker Wire

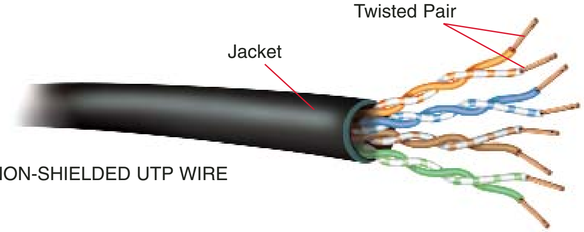
The speaker wire best suited for paging systems is 2 conductors in a jacket. The gauge of the conductors varies depending on the installation. In many instances, a shielded version of the speaker wire is used. The shield can be useful to help protect the conductors from receiving electrical interference from other electrical equipment in the area. The shield is particularly useful when speakers are to be used as microphones in talk back applications *(see page 50 for more information on talk back)*.



SHIELDED SPEAKER WIRE

UTP

Unshielded Twisted Pair wire has many uses but is most common in data and telecom installations. It uses solid conductors, typically 24 gauge. It has insulation to withstand voltages similar to speaker wire and can be used in 70V and self-amplified applications as long as the thin gauge, and the associated higher resistance is accounted for. Also, because there is no shield, the use of UTP in talkback applications (where the speaker acts as a microphone) may lead to higher electrical noise on the talkback signal. There are normally several twisted pair in a single cable and these can be paralleled to approximate lower gauge wires *(see page 75)*.



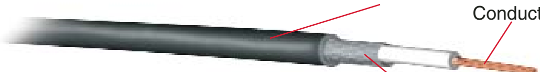
NON-SHIELDED UTP WIRE

Shielded Cable

Shielded cable refers to any conductor, or conductors, wrapped in an electrically conductive shield. The two types of cable most prevalent for audio installations are:

• *Single-Conductor Shielded Cable*

Single-conductor shielded cable is used to connect external equipment to the unbalanced AUX inputs of amplifiers. The center conductor carries the signal source and the shield carries the ground between the amplifier and external equipment. In addition to completing the ground return between the electrical equipment, the cable provides a large amount of noise and interference protection for the center conductor. The most common connector for this type of cable is the Phono connector (a.k.a. the RCA connector). The connector's center pin connects to the internal conductor and the skirt around the connector's perimeter connects to the shield of the cable.



SINGLE-CONDUCTOR SHIELDED CABLE

• *Two-Conductor Shielded Cable*

Two-conductor shielded cable is typically used with balanced microphones. Two internal conductors are required for the low impedance balanced microphones used in paging systems. The shield is wrapped around these conductors and provides the same protection against electrical interference and noise as single-conductor cable. Balanced microphone inputs provide a ground connection point for the shield. Without the ground connection, the shield would be ineffective. Some microphones with push-to-talk switches require two more conductors to carry the switch closure back to the amplifier. In this cable, the conductors for the switch closure are not wrapped in the shield but rather carried in the cable jacket outside of the shield. The most popular types of connectors for microphone cable are screw terminals and XLR connectors.



TWO-CONDUCTOR SHIELDED CABLE
(BALANCED MIC CABLE)

Wire-Related Losses

Wire is an important but often ignored component of a paging system. Because all wire has resistance, some of the voltage at the source is lost or dropped in the wire before it reaches the target destination. The amout of voltage lost in the wires is effected by the resistance or gauge of the wire and the current flowing in the wire. This is classic Ohm's law in action. If the drops in the cables are not anticipated, the final volume level at the passive speaker may not meet the requirement or, for a self-amplified speaker, there may not be engough DC voltage available to the speaker to allow the built-in amplifier to operate cleanly, or at all.

We use different charts for centralized and self-amplified speakers to determine the maximum cable lengths that should be allowed.

In the case of central amplifier systems we try to keep the system power lost in the wires to 10% or less. However, less power at the speaker is the only negative effect larger losses have on the system. Clarity, intelligibility and frequency response are unaffected by larger losses in the wiring of centrally amplified systems.

Self-amplified systems are particularly sensitive to losses in the wire, especially the amount of supply voltage that is lost in the wires on the way to the self-amplified speaker. When the drop in the wiring becomes too large, the speakers may begin to distort or stop functioning altogether. For this reason it is important to adhere to the maximums shown in the tables below.

Wire Loss In Central Amplifier Systems

Once you have an idea of how many speakers are to be wired together in a run, estimate how long the wire run will be from the first to the last speaker in each run. Include the lead-in wire length from the amplifier to the first speaker in each run in your overall run length. For each run, sum up the speaker power and cable lengths.

With that information, refer to the Wire Loss Chart to ensure that the wire gauge is sufficient to support the power and cable length for the run. It may be necessary to increase the wire gauge, split the speaker loads, or shorten the wire run lengths if they exceed the chart maximums.

Wire Loss Chart

(10% of Power Lost in Wire)

Wire Gauge	Load Power Per Wire Run (Watts)						
	5	10	15	30	50	100	200
16	10,000	7000	4600	2300	1400	700	350
18	9000	4500	2800	1400	830	415	205
20	5500	2700	1800	900	540	270	135
22	3400	1700	1100	550	330	115	60
24	2100	1000	700	350	210	105	50
	Maximum Wire Run Cable Length (ft.)						

Voltage Drop In Self-Amplified Systems

The most important wiring consideration with self-amplified speakers is to ensure that there will be enough voltage available at each device to allow its internal amplifier to operate correctly. If too much voltage is dropped in the wires leading to a speaker, this may not be the case.

Once you have an idea of how many speakers are to be wired together in a run, estimate how long the wire run will be from the first to the last speaker in each run. Include the lead-in wire length from the power supply to the first speaker in each run. Also sum up the CU ratings of all the speakers on the run.

With that information, refer to the Voltage Drop Chart to ensure that there are not too many speakers loading the wire used in the run or that the wire gauge is sufficient to support the power and cable length desired. To stay within the chart length limits it may be necessary to either create a shorter run containing less speakers or double up on conductors in the cable to effectively lower the gauge of the supply wire. The Reducing Gauge Chart can be used to determine what effective gauge is achieved by doubling or tripling up on pairs in the cable.

VOLTAGE DROP CHART

Total CU (Current Units) on cable run	WIRE GAUGE (AWG)					
	26	24	22	20	18	16
10	220'	351'	557'	887'	1413'	2237'
20	110'	175'	279'	443'	706'	1118'
30	73'	117'	186'	296'	471'	746'
40	55'	88'	139'	222'	353'	559'
50	44'	70'	111'	177'	283'	447'
60	37'	58'	93'	148'	235'	373'
70	31'	50'	80'	127'	202'	320'
80	28'	44'	70'	111'	177'	280'
90	24'	39'	62'	99'	157'	249'
100	22'	35'	56'	89'	141'	224'
110	20'	32'	51'	81'	128'	203'

Indicates maximum cable length (in feet)

REDUCING GAUGE

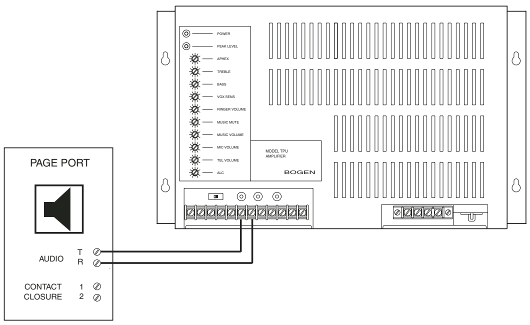
WIRE GAUGE (AWG)	GAUGE OF 2 PARALLEL PAIR	GAUGE OF 3 PARALLEL PAIR
26	24	22
24	22	20
22	20	18
20	18	16
18	16	14
16	14	12

Telephone Interfaces

The most common way to make announcements over a paging system is through the telephone system. It is a convenient and readily available live input source. However, audio and telephone technologies are different. This sometimes makes it necessary to use an adapter to link the two systems together.

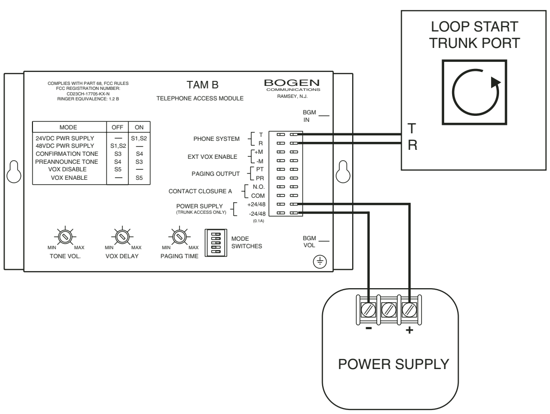
There are many types of telephone ports possible in telephone switches. The four types presented here – Page Port, Loop Start trunk, Ground Start trunk, and Analog ring-up station – are the only ones Bogen recommends as interfaces to telephone systems. Other port types and specifically digital station ports are not suitable for connection to amplifiers and interface devices.

Page Ports



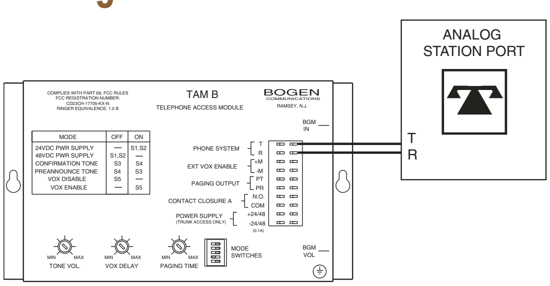
- Dedicated audio output available standard on most telephone systems
- Can be connected directly to the input of most amplifiers
- Traditionally a 600-ohm dry audio signal and a normally open control contact closure
- Control contacts, if available, activate during a page and typically control the muting of background music
- Some page ports provide only an audio pair, which requires that audio equipment have voice-activated (VOX) functions such as background music muting
- Paging ports are not always bi-directional like telephone lines (bi-directionality is necessary when including talk back capability in a paging system)
- Not all paging ports will produce DTMF tones which are necessary when using zone paging equipment

Loop And Ground Start



- The Loop Start, or CO port, is the most popular type of paging interface to use when a page port is not available or suitable
- A Ground Start trunk uses loop current but employs a request and acknowledgment hand shake for making the initial connection
- An interface device is necessary when connecting a trunk to an amplifier
- When paging, an interface adapter detects the off-hook condition of the trunk and connects the amplifier to the trunk port through signal conditioning electronics
- When the trunk is released, the adapter detects the on-hook condition and immediately disconnects the amplifier from the trunk
- Trunk interface adapters require a power supply to provide talk-battery and loop current to the trunk port
- A pop at the end of a page is typically present due to the large change in telephone line voltage between on- and off-hook conditions

Analog Station



- An analog station allows interfacing when neither a paging port nor a trunk port is available
- Analog ring-up interfacing requires a more sophisticated interface than other methods
- The interface must detect a high-voltage ring signal and answer the call to start the page
- To determine when to disconnect the page, typically two system timers are used — one limits the maximum length of the page to ensure disconnection, the other senses audio activity and disconnects after a preset length of silence
- Many telephone switches now provide calling party control (CPC) signal, which indicates to the interface that the caller has disconnected; Bogen interfaces disconnect immediately upon detecting a CPC signal

Sound Pressure Levels Chart

Typical Ambient Noise Level			Typical Environments	
Very High Noise	85-95 dB	Speech Almost Impossible To Hear	Construction Site Loud Machine Shop Noisy Manufacturing Printing Shop	95 dB
High Noise	75-85 dB	Speech is Difficult To Hear	Assembly Line Crowded Bus/Transit Waiting Area Machine Shop Shipping/Warehouse Supermarket (Peak Time) Very Noisy Restaurant/Bar	85 dB
Medium Noise	65-75 dB	Must Raise Voice to be Heard	Bank/Public Area Department Store Noisy Office Restaurant/Bar Supermarket Transportation Waiting Room	75 dB
Low Noise	55-65 dB	Speech is Easy To Hear	Conversational Speech Doctor's Office Hospital Hotel Lobby Quiet Office Very Quiet Restaurant/Bar	65 dB 55 dB